

Supplement of Hydrol. Earth Syst. Sci., 18, 4437–4452, 2014
<http://www.hydrol-earth-syst-sci.net/18/4437/2014/>
doi:10.5194/hess-18-4437-2014-supplement
© Author(s) 2014. CC Attribution 3.0 License.



Supplement of

Hydrogeology of an Alpine rockfall aquifer system and its role in flood attenuation and maintaining baseflow

U. Lauber et al.

Correspondence to: U. Lauber (ute.lauber@kit.edu) and N. Goldscheider (goldscheider@kit.edu)

Supplementary Material:

Table S1: Statistics of the two gauging stations GS-RU and GS-RD, n = number of measurements, R² = coefficient of determination, SE = standard error.

Gauging station	Observation period	n	R ²	SE
GS-RU	2002-2008	38	0.89	0.39
GS-RU	2010-2011	14	0.72	0.41
GS-RD	2002-2005	58	0.91	0.39
GS-RD	2005-2006	6	0.97	0.40
GS-RD	2007-2011	81	0.90	0.37

Table S2: Monthly mean discharge downstream from the alluvial/rockfall aquifer at GS-RD. The year 2006 is characterized by very low discharge in comparison with the other years.

	2002	2003	2004	2005	2006	2007	2008	2010	2011
	28.4.- 24.10.	18.7.- 11.12.	2.6.- 9.11.	11.3.- 18.11.	15.3.- 18.11.	10.2.- 6.12.	18.4.- 20.11.	2.3.- 24.11.	15.3.- 14.10.
February	-	-	-	-	-	0.24	-	-	-
March	-	-	-	0.8	-	0.31	-	0.41	0.46
April	-	-	-	1.18	0.48	0.70	0.92	0.62	0.84
May	2.66	-	-	2.35	0.95	2.86	2.13	1.85	1.75
June	3.74	-	3.55	3.54	1.75	3.83	4.33	3.52	2.60
July	3.28	-	3.99	3.63	1.32	2.64	2.54	2.92	2.22
August	3.46	-	2.81	2.68	2.75	1.63	2.92	2.35	1.87
September	2.25	1.4	2.06	1.50	1.28	-	1.77	1.74	1.33
October	1.88	1.46	1.82	1.35	0.81	-	1.07	0.93	1.40
November	-	0.84	-	0.91	-	0.40	0.73	0.94	-

Table S2: Discharge characteristics of selected precipitation events in 2006 and 2011. All events with a peak discharge $Q_P > 2.3 \pm 0.2 \text{ m}^3/\text{s}$ are high-flow events. [Q_i : initial discharge; Q_P : peak discharge; discharge response: ratio between direct discharge ($Q_P - Q_i$) and precipitation, conversion factor and catchment area ($P_{\text{peak}} \cdot f_c \cdot A$); discharge ratio: quotient between Q_P and Q_i , lag time: time difference between discharge peak upstream (GS-RU) and downstream (GS-RD) from the rockfall aquifers; Flow conditions indicate high-flow (HF) and low- to moderate flow conditions (LF/MF) of the individual events].

Event	Gauging station	P_{SUM}^a	Peak rainfall in 6h ^b	Q_i	Q_P	Discharge response	Discharge ratio	Lag time	Flow conditions ^d
-	-	mm	mm	$\text{m}^3 \text{ s}^{-1}$	$\text{m}^3 \text{ s}^{-1}$	-	-	h	-
1.8.2002	GS-RU	18	9	2,01	5,28	1,115	2,63	4,5	HF
	GS-RD			2,82	5,92	0,509	2,10		
4.8.2002	GS-RU	18	18	1,97	3,39	0,358	1,72	5,4	HF
	GS-RD			3,40	3,90	0,168	1,15		
6.8.2002	GS-RU	21	13	1,98	4,12	0,602	2,08	5,0	HF
	GS-RD			3,54	5,43	0,323	1,53		
11.8.2002	GS-RU	66	22	1,78	7,76	0,670	4,36	4,5	HF
	GS-RD			3,10	12,17	0,428	3,93		
20.8.2002	GS-RU	29	16	1,46	2,34	0,278	1,60	14	HF
	GS-RD			2,55	3,04	0,147	1,19		
1.9.2002	GS-RU	26	16	0,94	2,20	0,261	2,34	85 ^c	LF
	GS-RD			1,90	2,24	0,108	1,18		
29.8.2003	GS-RU	12	12	0,81	2,10	0,333	2,59	105 ^c	LF
	GS-RD			1,08	1,58	0,102	1,46		
10.9.2003	GS-RU	35	19	0,65	1,83	0,183	2,82	187 ^c	LF
	GS-RD			1,08	1,86	0,076	1,72		
4.10.2003	GS-RU	35	21	0,66	1,21	0,109	1,83	186	LF
	GS-RD			1,08	2,57	0,095	2,38		
20.8.2004	GS-RU	89	70	1,69	2,92	0,079	1,73	40	HF
	GS-RD			2,47	3,07	0,034	1,24		
26.8.2004	GS-RU	69	27	1,52	2,89	0,203	1,90	29	HF
	GS-RD			2,57	3,46	0,099	1,35		
22.9.2004	GS-RU	68	25	0,71	2,88	0,219	4,06	125 ^c	LF
	GS-RD			1,59	2,47	0,076	1,55		
30.9.2004	GS-RU	12	7	1,47	1,82	0,494	1,24	103 ^c	LF
	GS-RD			2,21	2,61	0,288	1,18		
16.8.2005	GS-RU	41	28	1,30	2,99	0,203	2,30	43	HF
	GS-RD			1,98	3,45	0,095	1,74		
2.10.2005	GS-RU	14	14	0,98	2,48	0,337	2,53	102 ^c	LF
	GS-RD			1,55	1,99	0,110	1,28		

Event	Gauging station	P _{SUM} ^a	Peak rainfall in 6h ^b	Q _i	Q _p	Discharge response	Discharge ratio	Lag time	Flow conditions ^d
-	-	mm	mm	m ³ s ⁻¹	m ³ s ⁻¹	-	-	h	-
20.5.2006	GS-RU	9	5	0,97	3,52	1,338	3,63	38	HF
	GS-RD			0,53	3,11	0,481	5,87		
28.5.2006	GS-RU	15	8	1,14	6,03	1,432	5,29	33	HF
	GS-RD			0,51	2,63	0,254	5,16		
7.8.2006	GS-RU	49	10	0,96	8,09	1,537	8,43	3,8	HF
	GS-RD			0,64	14,40	1,114	22,50		
18.9.2006	GS-RU	17	8	0,65	1,25	0,297	1,92	101 ^c	LF
	GS-RD			0,74	1,06	0,103	1,43		
27.9.2006	GS-RU	26	9	0,65	1,22	0,258	1,88	93 ^c	LF
	GS-RD			0,67	0,93	0,080	1,39		
4.10.2006	GS-RU	29	15	0,67	2,84	0,360	4,24	106 ^c	LF
	GS-RD			0,77	1,80	0,093	2,34		
26.6.2007	GS-RU	32	18	1,05	2,1	0,222	2,00	22	HF
	GS-RD			2,77	2,85	0,122	1,03		
2.7.2007	GS-RU	69	21	0,79	1,97	0,178	2,49	35	HF
	GS-RD			2,32	4,67	0,172	2,01		
9.7.2007	GS-RU	36	28	0,85	2,99	0,203	3,52	23	HF
	GS-RD			2,94	5,24	0,145	1,78		
24.7.2007	GS-RU	9	7	0,78	1,47	0,399	1,88	56	HF
	GS-RD			1,69	2,47	0,273	1,46		
9.8.2007	GS-RU	29	10	0,67	1,15	0,219	1,72	34	HF
	GS-RD			1,1	2,20	0,170	2,00		
16.8.2008	GS-RU	118	38	0,84	2,93	0,147	3,49	3,5	HF
	GS-RD			2,01	7,73	0,157	3,85		
11.9.2008	GS-RU	10	10	0,61	0,92	0,175	1,51	161 ^c	LF
	GS-RD			1,54	2,02	0,156	1,31		
17.7.2010	GS-RU	45	18	1,41	3,06	0,323	2,17	3,2	HF
	GS-RD			2,35	3,9	0,168	1,66		
23.7.2010	GS-RU	37	25	1,14	2,45	0,186	2,15	4,3	HF
	GS-RD			2,03	2,83	0,088	1,39		
25.9.2010	GS-RU	45	24	0,56	0,64	0,051	1,14	83 ^c	LF
	GS-RD			1,16	1,27	0,041	1,09		
13.11.2010	GS-RU	12	6	0,31	0,55	0,174	1,77	122 ^c	LF
	GS-RD			0,89	1,01	0,130	1,13		
18.6.2011	GS-RU	39	20	1,65	3,77	0,358	2,28	9,5	HF
	GS-RD			2,58	4,96	0,192	1,92		
30.6.2011	GS-RU	30	16	1,34	4,02	0,477	3,00	29	HF
	GS-RD			2,04	3,08	0,149	1,51		
7.8.2011	GS-RU	55	31	0,88	2,65	0,162	3,01	36	HF
	GS-RD			2,00	3,45	0,086	1,73		
5.9.2011	GS-RU	53	21	0,52	1,96	0,177	3,77	86 ^c	LF
	GS-RD			1,04	1,71	0,063	1,64		

Event	Gauging station	P _{SUM} ^a	Peak rainfall in 6h ^b	Q _i	Q _p	Discharge response	Discharge ratio	Lag time	Flow conditions ^d
-	-	mm	mm	m ³ s ⁻¹	m ³ s ⁻¹	-	-	h	-
18.9.2011	GS-RU	19	15	0,46	1,2	0,152	2,61	105	LF
	GS-RD			1,00	1,6	0,083	1,60		
10.10.2011	GS-RU	31	12	0,45	3,16	0,500	7,02	34	HF
	GS-RD			0,9	2,87	0,185	3,19		
mean values (excluding extreme event in 2006)			GS-RU	1,04	2,65	0,389	2,65		
			GS-RD	1,80	3,22	0,188	1,93		

^a Sum of precipitation until peak discharge at GS-RU

^b Note that maximum resolution of sum of precipitation is 6 h

^c Obtained by impulse-response-analysis

^d predominant flow conditions: high-flow conditions (HF) and low flow conditions (LF); mean-flow conditions (MF) are mainly a transition between LF to HF and therefore are not listed separately

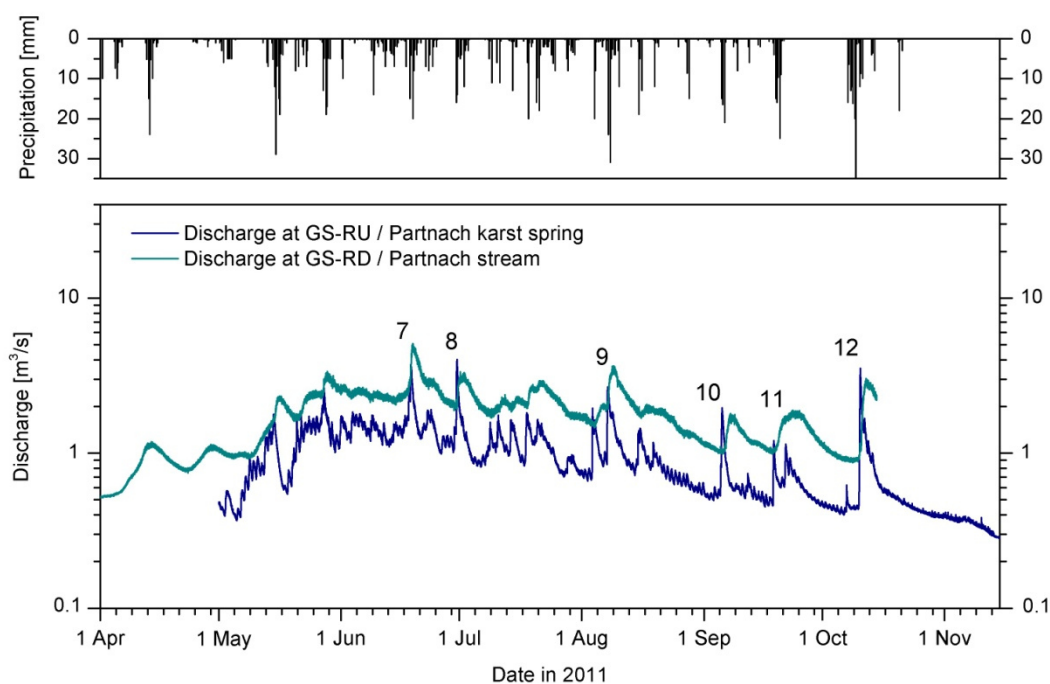


Figure S1. Hydrographs at the upstream (Partnach karst spring, site GS-RU) and downstream (Partnach stream, site GS-RD) gauging stations in the Reintal valley in 2011. Precipitation data (6-h time step) was obtained from the weather station at Mt. Zugspitze (DWD).

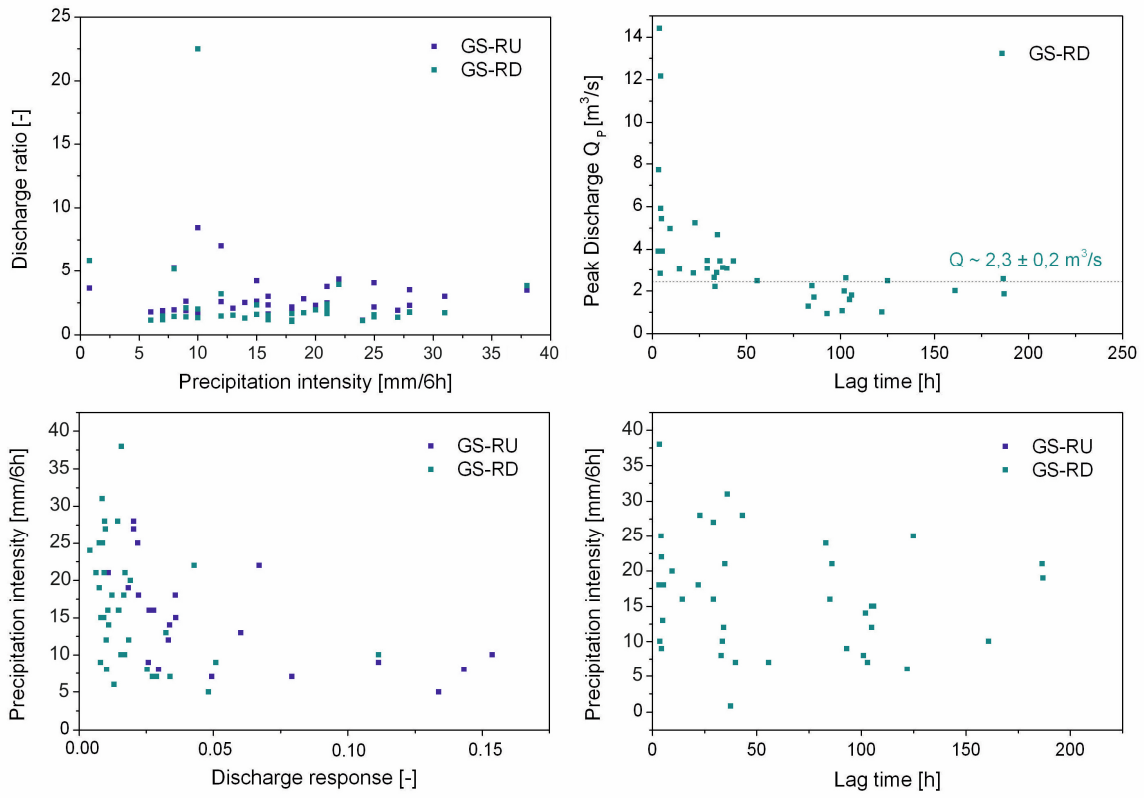


Figure S2. a) Precipitation intensity vs. discharge ratio, b) lag time vs. peak discharge, c) discharge response vs. precipitation intensity, and d) lag time vs. precipitation intensity at the gauging stations upstream (GS-RU) and downstream (GS-RD) from the alluvial/rockfall aquifer.